Electronic supporting information

Cascade utilization of lignocellulosic biomass to high-value products

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Table S1 The compositions of cellulose, lignin, hemicellulose in lignocellulosic biomass.

Type of biomass	Lignocellulosic substrate	Cellulose (%)	Hemicellulose (%)	Lignin (%)	Reference
Agriculture waste	Rice straw	27–46	22–35	6–23	
	Corn stover	30–51	23–31	7–23	
	Wheat straw	43.23	25.56	20.45	1
	Cotton stalk	50.5	11.7	19.4	2
	Sorghum stalk	38.2	33.0	9.9	3
	Rapeseed straw	/	/	28.38	4
	Corn cop	30–40	34–41	7–18	
	Rapeseed hulls pulps	12.01	15.47	/	5
	Sugarcane bagasse	21–49	13–27	21–27	
	Groundnut shells	37	18.7	28	6
	Sunn hemp	46.5	23	16	7
Forestry waste	Catalpa sawdust	50.87	17.21	18.95	8
	Birch sawdust	35	/	19.91	9
	Eucalyptus sawdust	41.35	27.79	26.31	10
	Spruce sawdust	55.4	/	28.7	11
	Oak sawdust	44.7	/	26.7	11
	Pine sawdust	42.6	29.5	25.2	12
	Beech wood	51.3	28.0	19.6	13
	Poplar wood	45.08	19.79	22.53	14
	Bamboo	45.58	19.95	26.5	15
	Lodgepole pine	/	/	30.5	16
	Oil palm	25.5	40	22.8	17
	Oil palm frond	30.7	41.5	27.8	18
Domestic wastes	Fruits and vegetable waste	25	/	16.7	19
	Grape	18.8	6.8	23.9	20
	Empty fruit bunch	36.7	22.8	24.2	21,22
	Olive pomace	11	24.1	41.62	23

	Coconut coir	44.2	22.1	32.8	[6]
	Pistachio shells	15.2	38.2	29.4	[6]
Grass	Elephant grass	34.6	24.3	15	[24]
	Napier grass	42	16.2	14.35	[25]
	Guinea grass	29.9	40.65	14.328	[26]
	Switchgrass	32.4	/	17.3	[27]
	Denanath grass	/	/	19.0	[28]
	Grass clipping	42.21	34.25	6.17	[29]
	Water hyacinth stems and leaves	19.63	33.63	26.13	[30]
	Saccharum spontaneum	49.3	11.7	23	[31]
	Lantana camara	38.3	23.5	27.2	[31]
	Eichhornia crassipes	47.3	34.9	4.1	[31]
	Mikania micrantha	50.2	11.3	19.1	[31]
	Big bulestem	44.4	28.6	6.9	[32]
	Reed	/	/	22	[33]
	Miscanthus	/	/	20	[16]
Industrial waste	Waste paper from chemical pulps	60–70	10–20	5–10	[34]
	Organic compound from wastewater solid	8–15	/	/	[34]
Animal manure	Cattle manure	14–27	12–22	6–13	
	Swine manure	13–15	20–22	5–6	
	Poultry manure	8–15	16–22	3–7	

Table S2 Examples of xylan types in different plant materials and monosaccharide compositions.[35]

Lignocellulosic biomass	Xylan type	Monosacchharide composition (%)					
		Xyl	Glc	Ara	Gal	Man	Uronic acid
Aspen wood chips[b]	4-O-methylglucuronoxylan	16.7	41.1	/	/	3.9	/
Birch wood chips[a]	4-O-methyl glucuronoxylan	66.9	1.4	3.2	4.2	/	/
Wheat straw[a]	arabinoglucuronoxylan	63.2	16.2	15.1	4.4	0.5	5.5
Rice husk[c]	arabinoxylan	15.9	34.0	1.8	/	/	/
Corn fiber[a,c]	arabinoglucuronoxylan[d]	17.2	/	13.7	5.6	/	/
Ryegrass leaves[a]	galactoarabinoxylans, L-arabino (4-O-methyl-D-glucurono)xylans	26.0	24.2	19.8	19.1	/	/
Rye bran	arabinoxylan	46.1	4.5	45.1	4.3	/	3.1
Palmaria palmate[a]	homoxylan	37.1	3.6	/	2.2	/	/

a: % (w/w) of total extracted material; b: % (w/w) in original wood sample; c: sugar composition is expressed as polymeric glucan, xylan and arabinan; d: arabinoxylan is acetylated, acetyl groups: 1.6%; Monosaccharides: Ara-arabinose, Xyl-xylose, Glc-glucose, Man-mannose, Gal-galactose.

Abbreviations:

2D	Two-dimensional
2-HTEAFmesy	Tris(2-hydroxyethyl)ammonium Methanesulfonate
A1A	N,N-diethyl-N,N-dimethylammonium Ascorbate
A1Ac	N,N-diethyl-N,N-dimethylammonium Acetate
A1C	N,N-diethyl-N,N-dimethylammonium Citrate
A1F	N,N-diethyl-N,N-dimethylammonium Formate
A1G	N,N-diethyl-N,N-dimethylammonium Gluconate
A1P	N,N-diethyl-N,N-dimethylammonium Phosphate
AEAPMDS	N-(2-Aminoethyl)(3-aminopropyl)methyldimethoxysilane
AL	Alkali lignin
AM	Acrylamide
AmimCl	1-Allyl-3-methylimidazolium Chloride
AmimHCOO	1-Allyl-3-methylimidazolium Formate
AmmorphAc	N-allyl-N-methylmorpholinium Acetate
AOPAB	4-[(4-acryloyloxyphenyl)azo]benzoic acid
APS	N-(2-aminoethyl)-3-aminopropylmethyldimethoxysilane
BET	Brunauer-Emmett-Teller
BHEMmesy	2-Hydroxy-N-(2-hydroxyethyl)-N-methylethanaminium Methanesulfonate
BmimAce	1-Butyl-3-methylimidazolium Acesulfamate
$BmimBF_4$	1-Butyl-3-methylimidazolium Tetrafluoroborate
BmimCl	1-Butyl-3-methylimidazolium Chloride

$BmimHSO_4$	1-Butyl-3-methylimidazolium hydrogen Sulfate
$BmimPF_6$	1-Butyl-3-methylimidazolium Hexafluorophosphate
CA	Cellulose acetate
CD	Carbon dot
CDC	6-Chloro-6-deoxycellulose
ChAc	Cholinium Acetate
ChArg	Cholinium Argininate
ChBu	Choline Butanoate
ChCl	Choline chloride
ChLys	Cholinium Lysinate
ChOrn	Cholinium Ornithine
CMC	Carboxymethyl cellulose
CMDEAEC	Carboxymethyldiethylammoniumethyl cellulose
CNCC	Cationically modified nanocrystalline cellulose
CNDs	Carbon nanodots
CNFs	Cellulose nanofibers
CNOs	Carbon nano-onions
CNTs	Carbon nano-tubes
CVD	Chemical vapor deposition
$DBNHCO_2Et$	1,5-Diazabicyclo[4.3.0]non-5-enium propionate
DES	Deep eutectic solvent
DIPEAAc	Diisopropylethylammonium Acetate
DIPEAB	Diisopropylethylammonium Benzoate
DIPEAO	Diisopropylethylammonium Octanoate
DIPEAP	Diisopropylethylammonium Propanoate
DMEAmesy	2-Hydroxy-N,N-dimethylethanaminium Methanesulfonate
DMSO	Dimethyl sulfoxide
DP	Degree of polymerization
DWNT	Double wall carbon nanotubes
EC	Ethyl cellulose
EmimAc	1-Ethyl-3-methylimidazolium Acetate
$EmimBF_4$	1-Ethyl-3-methylimidazolium Tetrafluoroborate
EmimCl	1-Ethyl-3-methylimidazolium Chloride
EmimDEP	1-Ethyl-3-methylimidazolium Diethyl phosphate
$EmimHSO_4$	1-Ethyl-3-methylimidazolium Hydrogen sulfate
$EmimMeOHPO_2$	1-Ethyl-3-methylimidazolium Methylphosphonate
$FurEt_2NHH_2PO_4$	N-Ethyl-N-(furan-2-ylmethyl)ethanamine Dihydrogen phosphate
GPC	Graphene-like porous carbon
GQDs	Graphene quantum dots
$HbimHSO_4$	1-Butylimidazolium Hydrogen sulfate
HC	Hemicelluloses
HmimCl	1-H-3-methylimidazolium Chloride
$HmimHSO_4$	1-Methylimidazolium Hydrogen sulfate
HnmpCl	N-Methyl-2-pyrrolidonium Chloride

HPMC	Hydroxypropyl methylcellulose
HPNC	Hierarchical porous nitrogen-carbon
HpyCl	Pyridinium Chloride
HSAL	Hydroxypropyl sulfonated alkaline lignin
HVED	High voltage electrical discharges
ILs	Ionic liquids
KPS/TMEDA	Potassium persulfate/N,N,N′,N′-tetramethylethylenediamine
LPU	Lignin-PCL Polyurethane
LSAL	Light-coloured SAL
MAHX	Modified xylan
MBA	N,N-Methylene-bis(acrylamide)
MCC	Microcrystalline cellulose
MMT	Montmorillonite
$N_{2220}HSO_4$	Triethylammonium Hydrogen sulfate
NaSL	Sodium lignosulfonate
NCC	Nanocrystalline cellulose
NSFC	Naphthalene sulfonate formaldehyde condensates
p-Anis$Et_2NHH_2PO_4$	N-Ethyl-N-(4-methoxybenzyl)ethanamine Dihydrogen phosphate
PCL	Poly(*ε*-caprolactone)
PDAMEMA	Poly (2-dimethylaminoethyl methacrylate)
PEF	Pulsed electric field
PILs	Poly(ionic liquids)
PLA	Polylactic acid
QH	Quaternized hemicelluloses
rGO	Reduced graphene oxide
SAL	Sulfonated alkali lignin
SB	Sorbitol
SC-CO_2	Supercritical CO_2
SC-ethanol	Supercritical ethanol
SC-H_2O	Supercritical water
SCW	Subcritical and supercritical water
SDS	Sodium dodecyl sulphate
SNF	Sodium naphthalene sulfonic
TAC	Triacetyl cellulose
TBAH	Tetra-n-butylammonium hydroxide
TBAOH	Tetrabutylammonium Hydroxide
$TEAHSO_4$	Triethylammonium Hydrogen sulfate
$TEAMeSO_3$	Triethylammonium Methanesulfonate
TEMPO	2,2,6,6-Tetramethylpiperidine-1-oxyl
T_g	Glass transition temperatures
TPs	Type polyphenols
$VanEt_2NHH_2PO_4$	4-((Diethylamino)methyl)-2-methoxyphenol Dihydrogen phosphate
ZNSRC	ZnO nanosheets-regenerated cellulose film

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